EOC OPERATIONS

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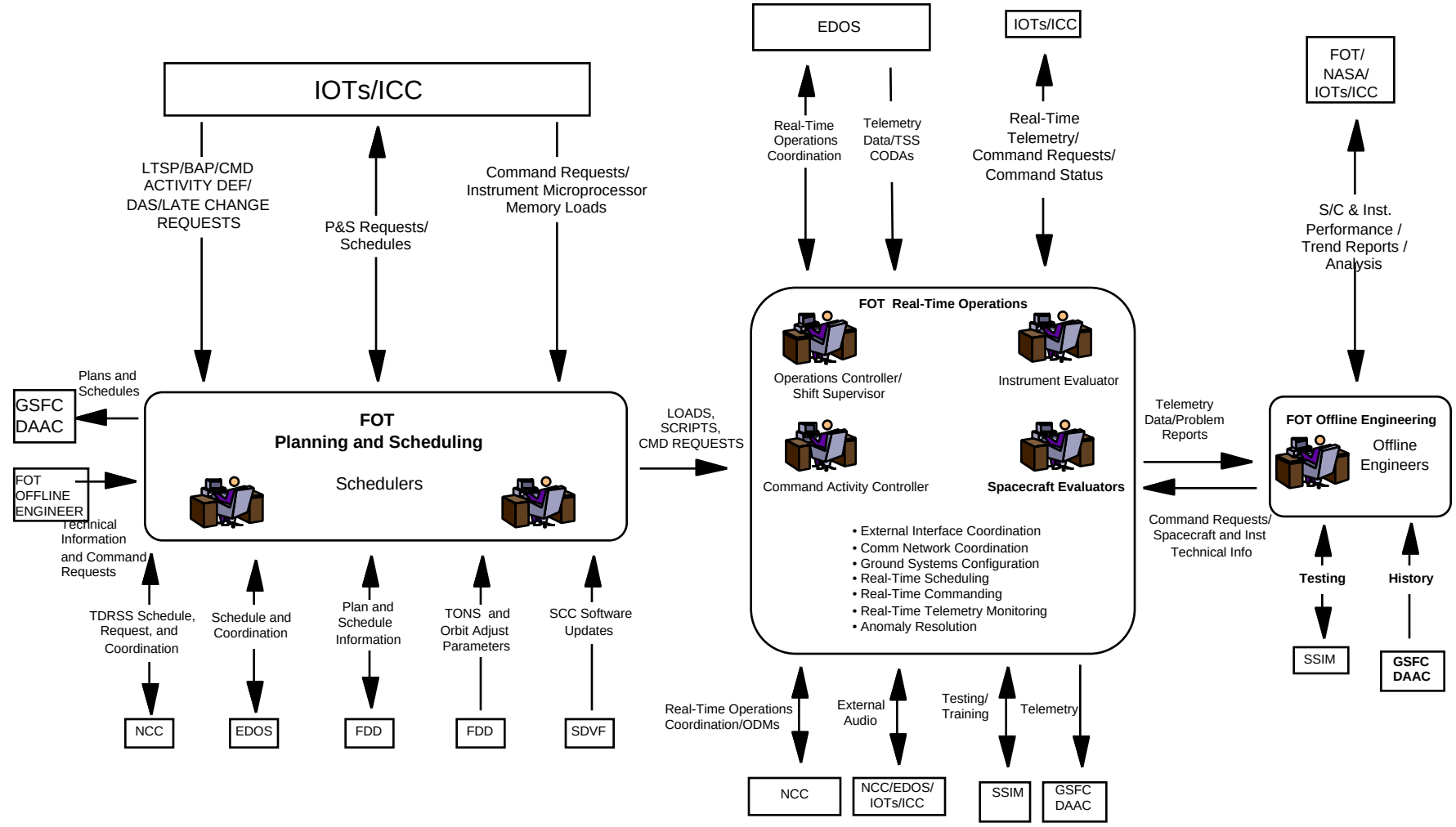
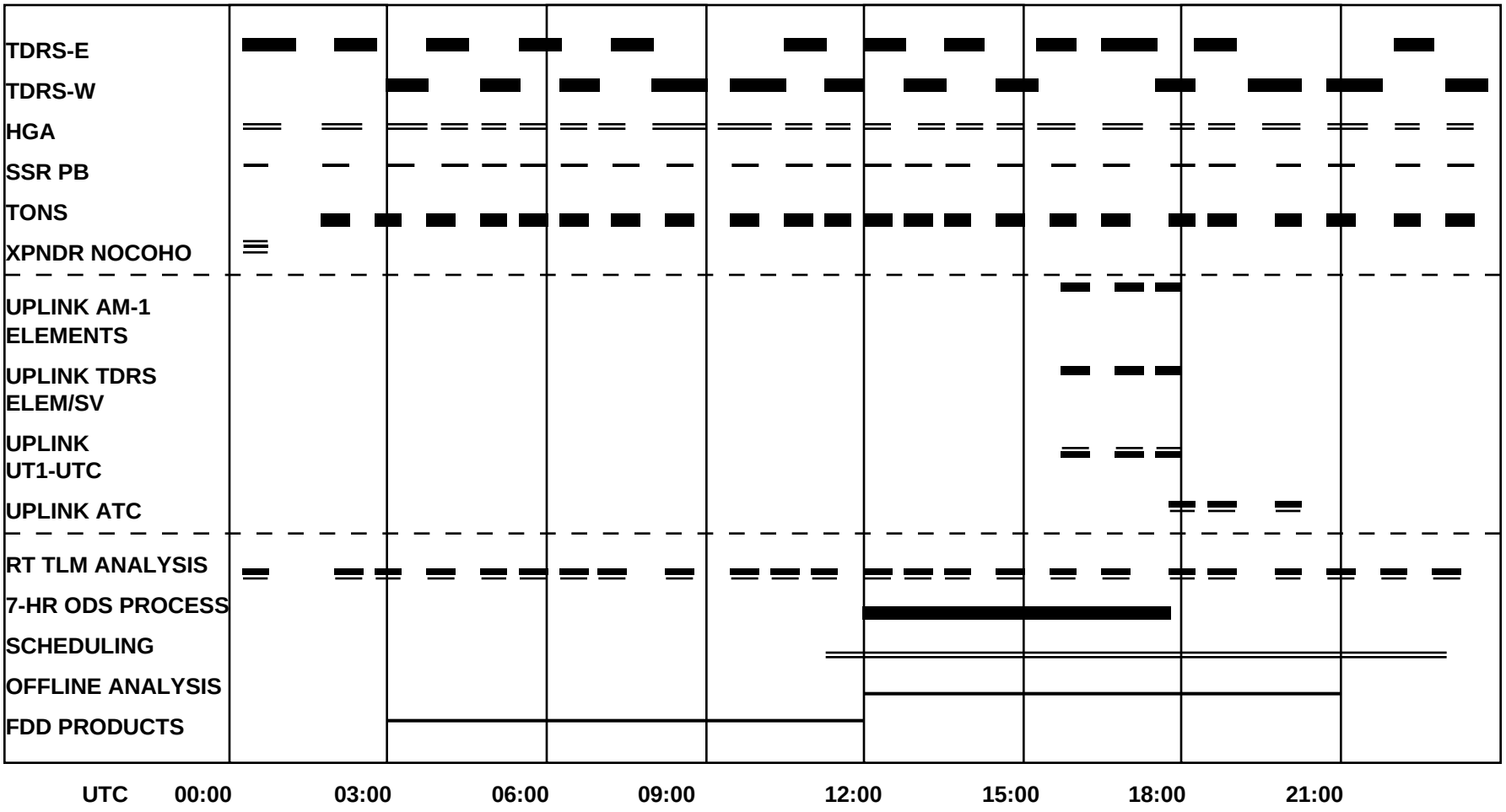
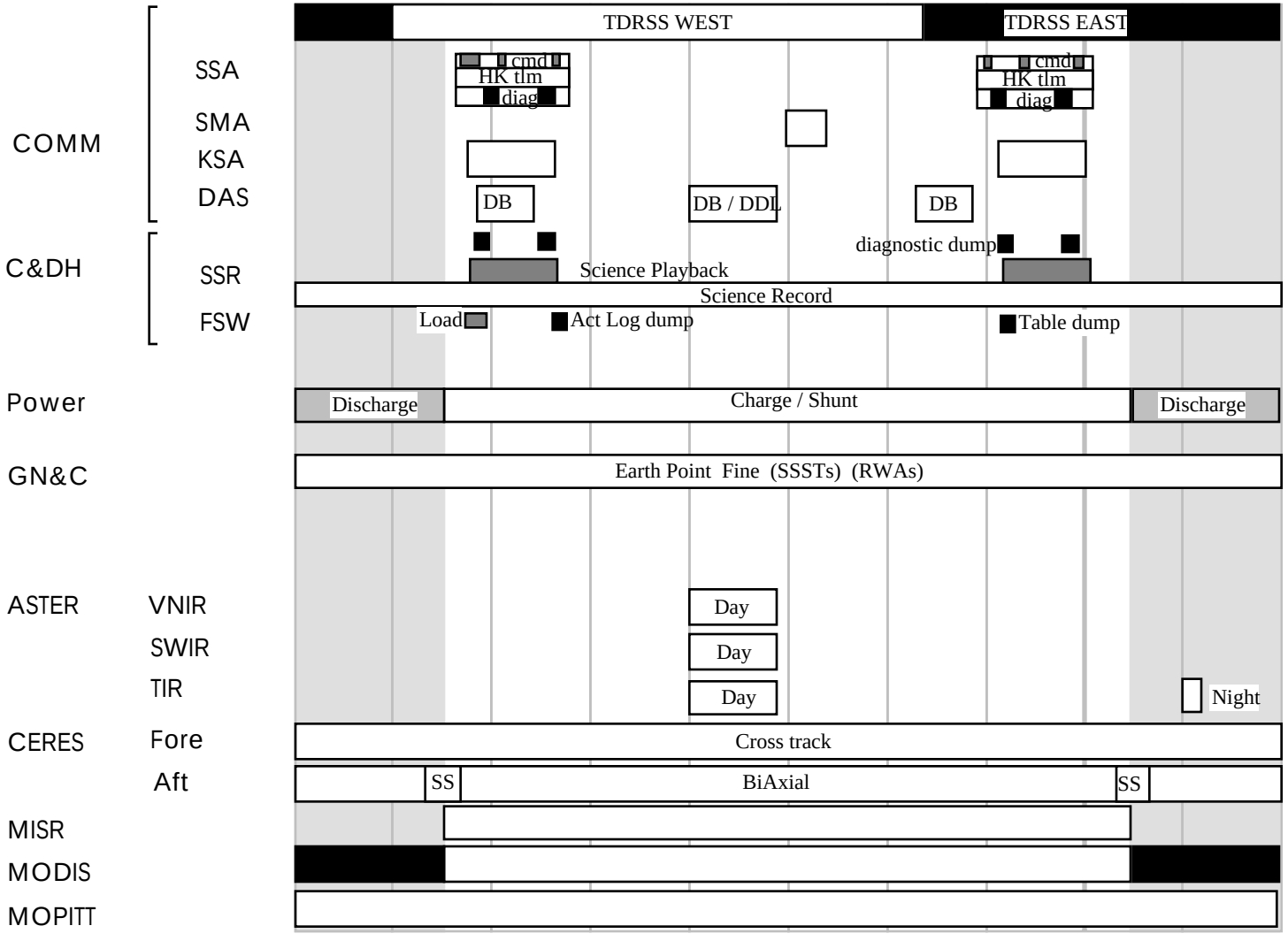
FOT Day in the Life



FOT Day in the Life 24-Hour Operations Profile (AM-1)



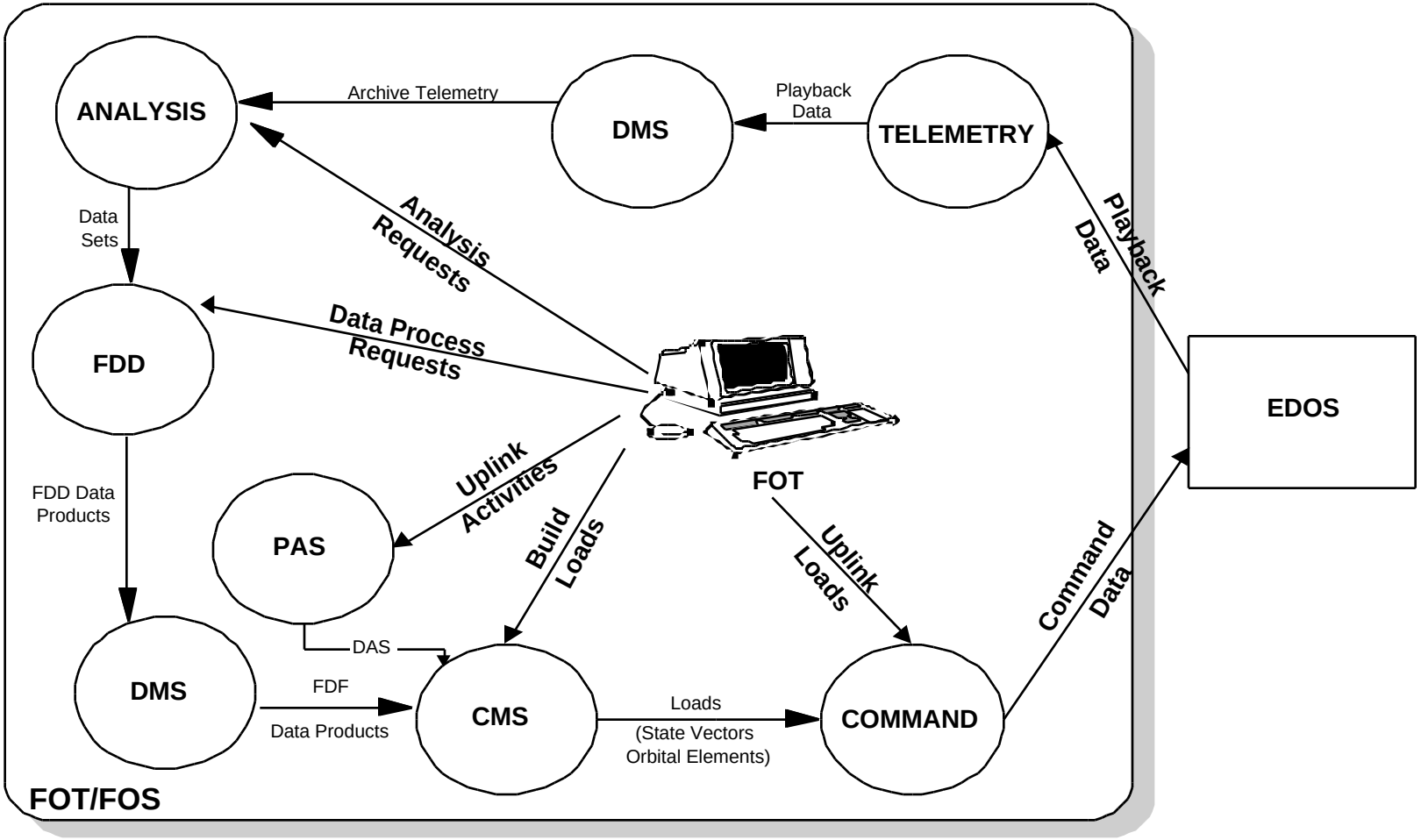
EOS AM-1 Typical Science Orbit



FDD-Provided System Support

- **FOT will**
  - **Receive training on FDD systems prior to launch**
  - **Jointly operate FDD systems during launch and checkout**
  - **Provide two engineers for orbit and attitude evaluations**
  - **Provide online engineers to generate routine planning products and acquisition data**
  - **Provide FDD system performance reports to FDD**
  - **Provide AM-1's GN&C system performance reports to FDD**

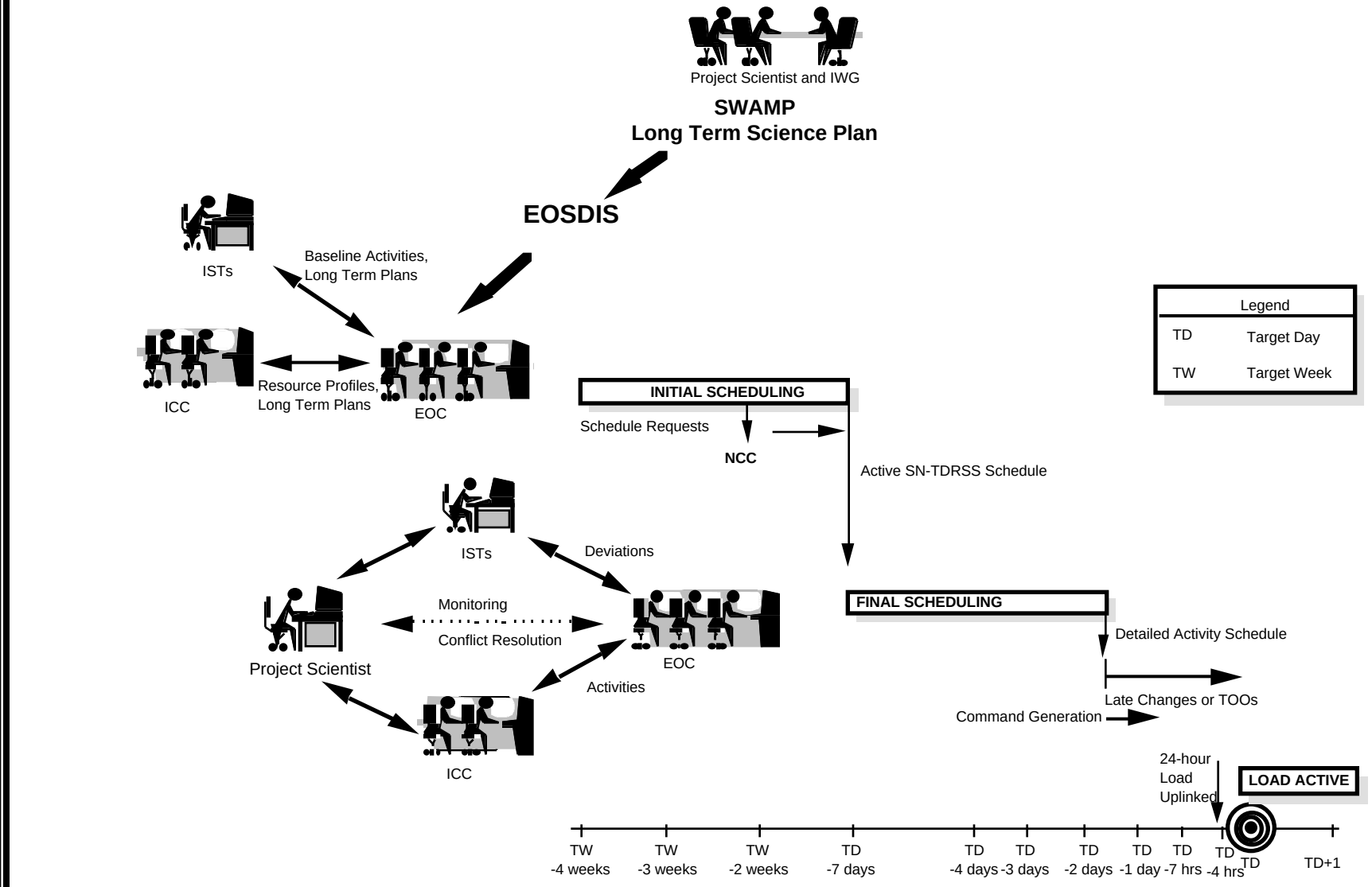
FDD Product Flow



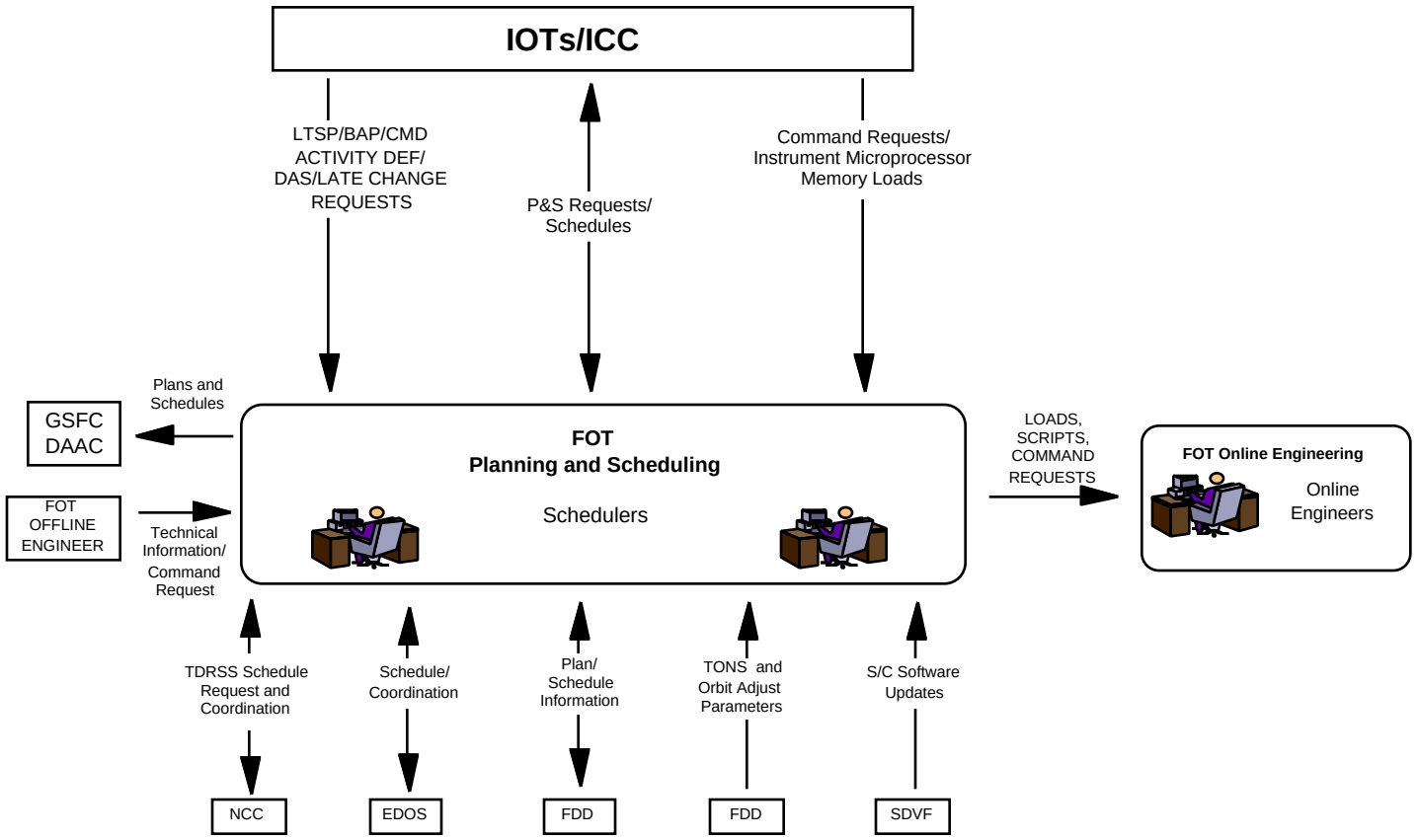
FDD Product Flow (Cont'd)

- Online engineers establish analysis standing orders to generate telemetry data sets that are transferred to FDD workstations
- Online engineers execute FDD software to generate planning products, acquisition data, and loads for AM-1
- Online engineers are responsible for product QA
- Schedulers informed of new FDD product availability
  - Update PDB
  - Inform IOTs of new products
  - Compile uplink loads
  - Update FOS resource model
- FDD load uplink activities scheduled automatically and added to ground script
- FOT is alerted of available loads for uplink
- FOT uplinks loads to AM-1 during a TDRS contact

EOS Mission Planning and Scheduling Overview



FOT Planning and Scheduling Interfaces and Functions



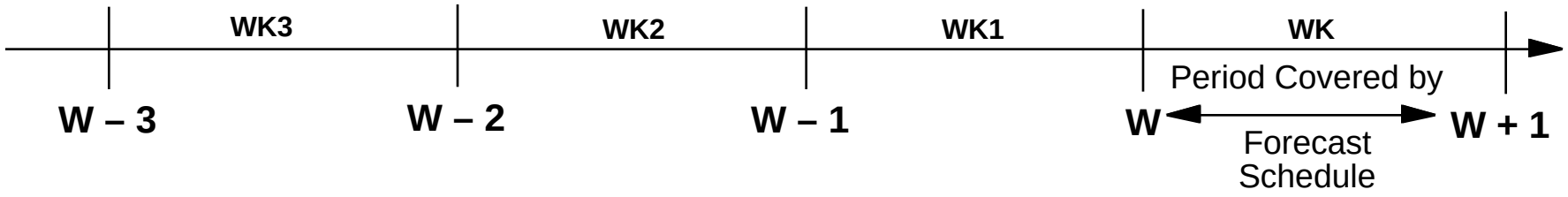
SN/Ground Station Scheduling

- Automated communications contact scheduling algorithm
  - Tunable via FOT
  - SSR model input
  - Antenna views input
  - Capable of multiple runs
- Manual conflict resolution with the NCC
- Ground station contingency support
  - Worked through NCC or Wallops
  - Used in event of TDRS unavailability

FOT Scheduling

- FOT schedulers are responsible for
  - Populating spacecraft activities on Timeline
  - Formulating TDRS schedule
  - Generating AM-1 loads
  - Generating AM-1 ground script
  - Scheduling uplink of command loads
- Activity definitions, RTCSs, and procedures used during scheduling process are maintained under CCB
- ATC load and ground script are built from activities and commands entered on timeline
- ATC load controls operation of spacecraft and selected instruments
- Ground script is used by FOT as guideline for real-time command execution
- ATC load and ground script are generated simultaneously
- FDD loads generated and scheduled

NCC-EOS TDRSS Scheduling Timeline



Forecast Schedule Requests Period

FOT submits TDRSS schedule requests

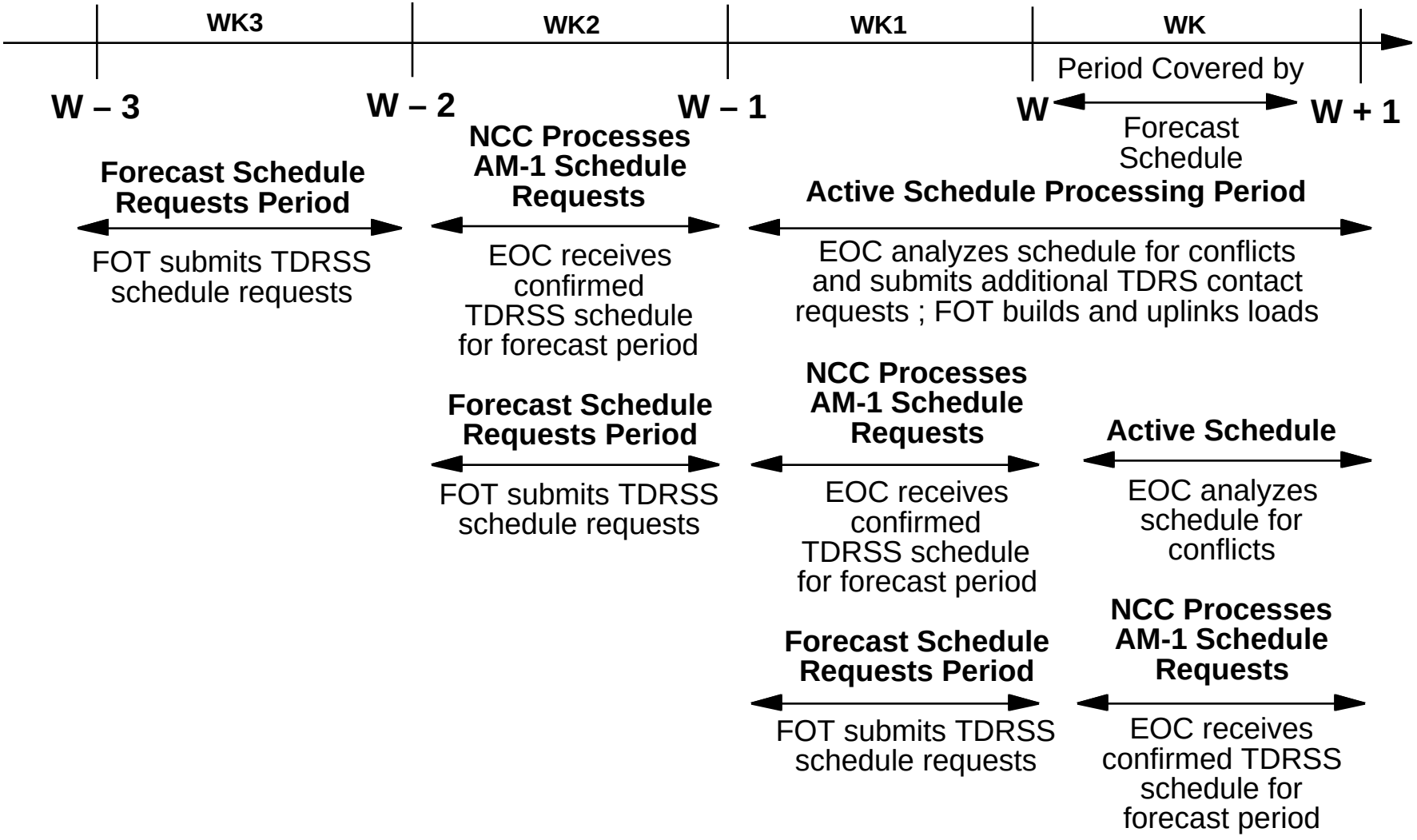
NCC Processes AM-1 Schedule Requests

EOC receives confirmed TDRSS schedule for forecast period

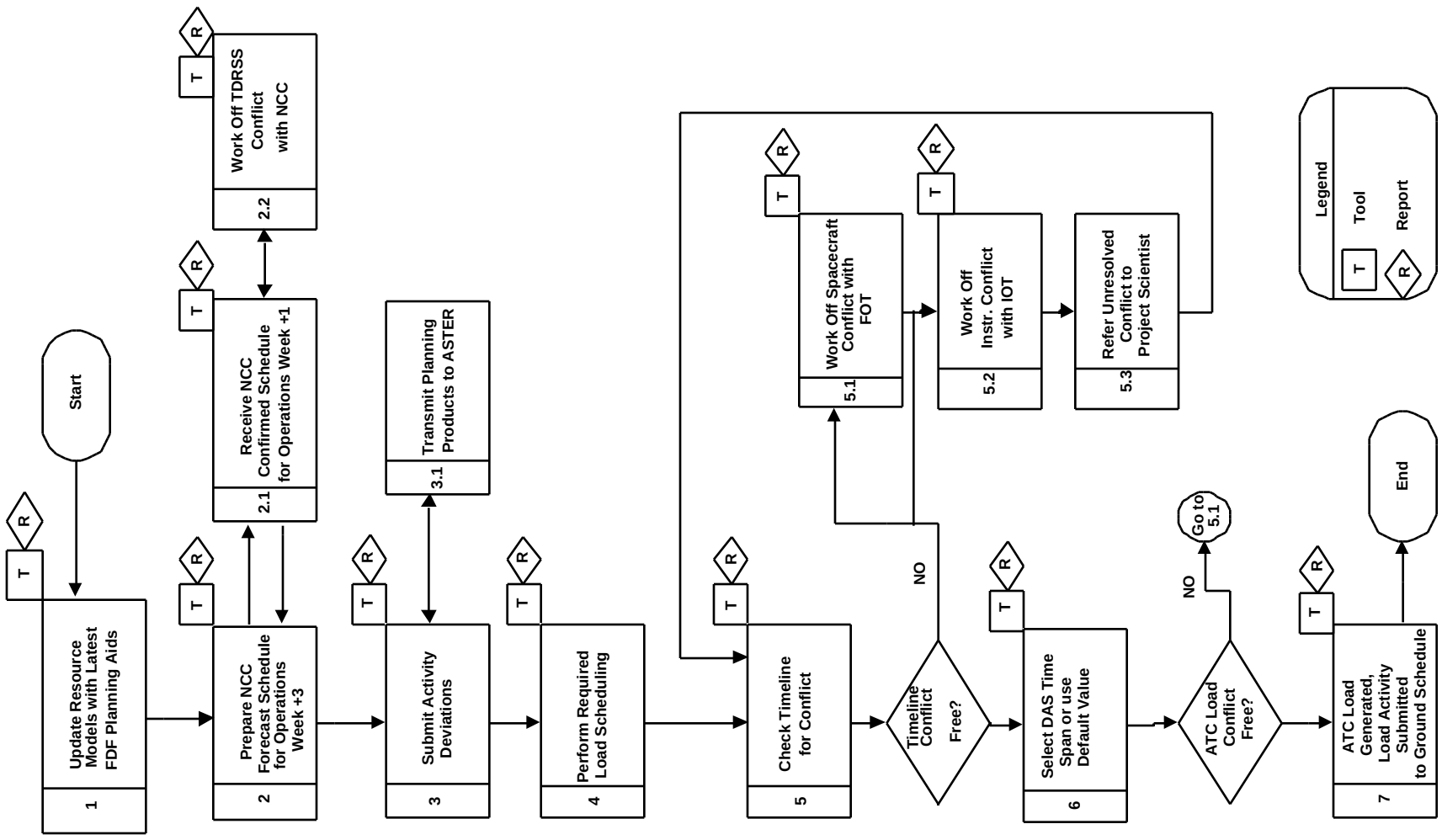
Active Schedule Processing Period

EOC analyzes schedule for conflicts and submits additional TDRS contact requests; FOT builds and uplinks loads

NCC-EOS TDRSS Scheduling Timeline: Day in the Life



FOT Scheduling Scenario Flowchart



SCC Table Loads

- Tables required for routine operations will be built automatically by FOS
- Content integrity will be verified by FOS and FOT
- Tables will be placed into ground schedule for subsequent uplink
  - Orbit elements
  - State vectors
  - UT1-UTC conversion coefficient
- FOT uses FOS Load Catalog to track all loads uplinked to spacecraft
- Contents of all loads will be archived
- Tables required for contingency operations will be built as identified (pre- and postlaunch) by responsible subsystem engineer
- Contingency tables are maintained for life of mission, as appropriate
- Procedures will be defined to control uplink of contingency tables
- FOT uplinks tables at direction of responsible subsystem engineer

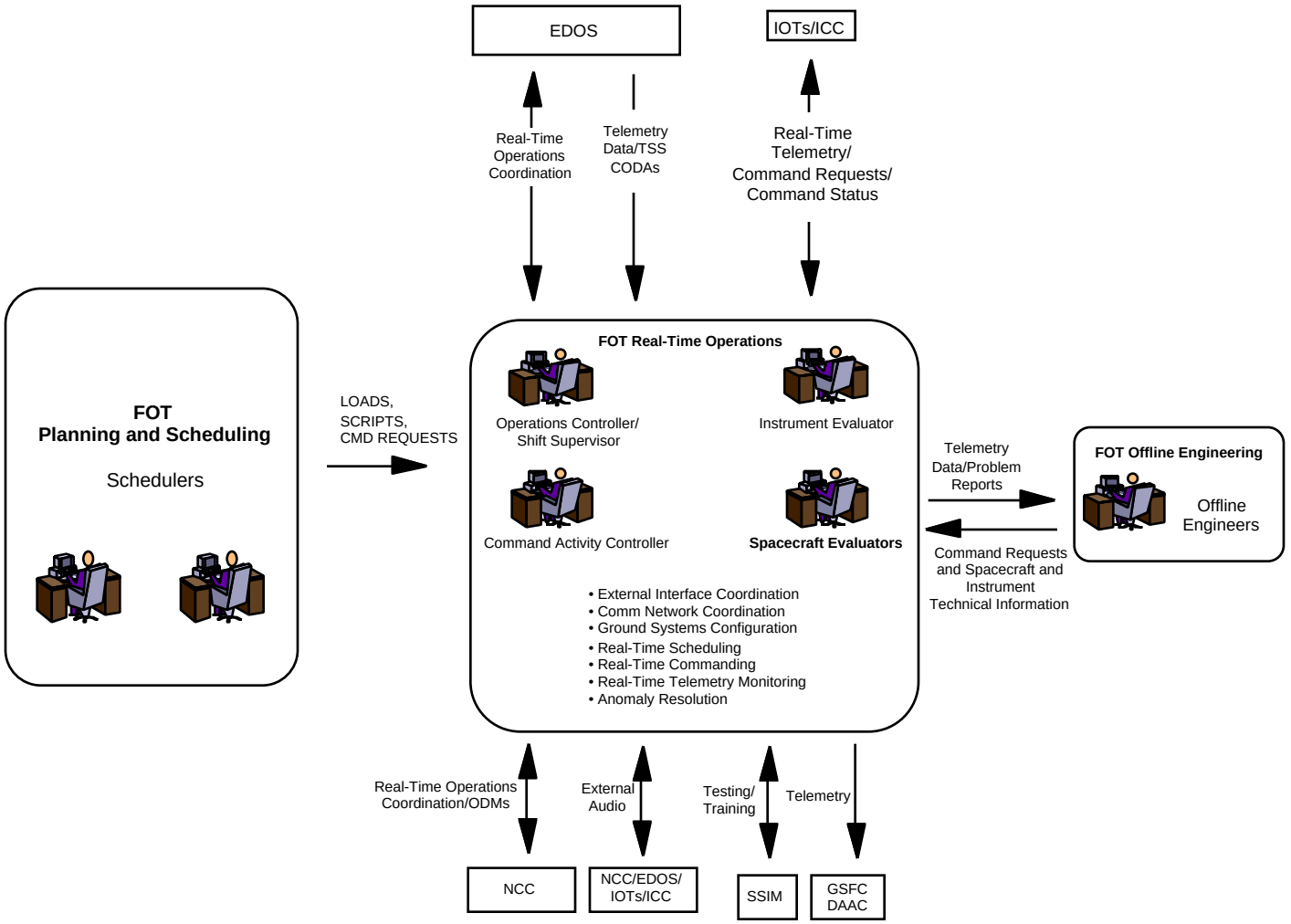
Instrument Microprocessor Loads

- The following items are being documented in the OICDs:
  - IOT delivers uplink file to FOS via IST tools
  - ASCII interpretive listing of load content provided to FOT
  - Uplink instructions provided to FOT via an authorized command request
  - Voice coordination between Operations Controller and IOT performed prior to targeted real-time contact; FOT/IOTs monitor uplink
  - Successful uplink feedback provided to FOT
  - All microprocessor loads are archived

Product Summary

Product	Activities	Command Procedures	Relative Time Sequence	Real-Time Commands
1. Who creates?	IOTs and FOT (jointly)	IOTs and FOT (jointly)	IOTs and FOT (jointly)	IOTs, LMVF, FOT
2. Where saved?	EOC database	EOC	Spacecraft	EOC database
3. Activated by	Event driven: a. Absolute time b. Day-to-night transition c. Night-to-day transition event d. Any orbital event e. etc.	EOC FOT: Ground script or human driven: a. Ground script initiated b. CAC initiated	EOC FOT or spacecraft	EOC FOT/IOT request
4. Used	Daily	As required	Daily	Daily

FOT Real-Time Functions and Interfaces



AM-1 Real-Time Support Baseline

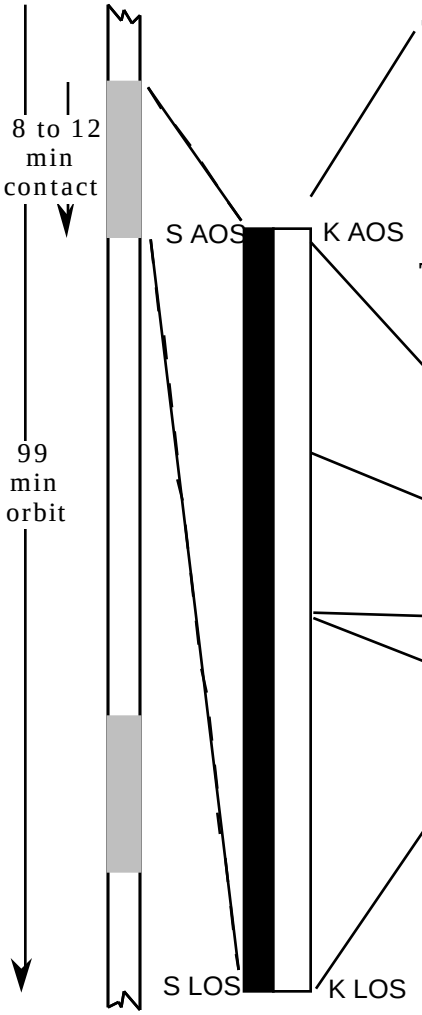
- Two 12-minute TDRS single access S-band/Ku-band real-time contacts per orbit
- SSR buffers played back every TDRS single access S-band/Ku-band real-time contact
- One noncoherent S-band event per day to directly measure master oscillator frequency
- Remaining S-band events are coherent to support TONS and clock correlation
- Events scheduled with minimum separation of 20 minutes and maximum separation of 60 minutes
- All Ku-band events are noncoherent
- Uplink TDRS state vector and orbit elements daily
- Uplink AM-1 orbit elements daily
- Uplink UT1-UTC coefficient daily
- Uplink stored commands daily
- Evaluate status of AM-1 spacecraft and instruments via real-time telemetry
- Evaluate quality of SSR playback data via NCC, EDOS, and DSS messages

FOT's 3-Step Approach for Real-Time Support

- **Step 1: Precontact**
  - Starts at acquisition of signal (AOS) -20 minutes
  - Involves planning and organizing for upcoming contact
  - Offline engineers brief Operations Controller on engineering activities
  - IOTs brief Operations Controller on instrument command activities, as appropriate
  - Online engineers brief Operations Controller on expected state of spacecraft and instruments
  - Operations Controller prioritizes commanding
  - Operations Controller briefs NCC and EDOS on SSR playback, Q channel data rate changes
  - Operations Controller briefs FOT on order of commands for upcoming contact
  - Command Activity Controller (CAC) tests FOS and links to EDOS for integrity

Nominal EOS AM-1 Contact

SSA/KSA Science Data Retrieval and Housekeeping Telemetry



TONS OBDC enabled FCW sent to XPNDR
S-band transmitter and SFE configured and commanded ON via ATC prior to SHO time
KSA TWTA commanded ON 2 sec prior to SHO idle pattern

SSA and KSA SHO return service start time are same

Transponder Acquisition (Carrier, Short PN, Long PN) ***TGT RF LOCK - NOLOCK status via ODMs***

16-kbps housekeeping telemetry available

TONS Doppler processing
Housekeeping Telemetry check

No-OP CMD
SSR Playback command
Sequential playback of buffers; average 6 minutes

Monitor telemetry, UPD, CODAs

Transmit required commands and loads

End of scheduled SSR Playback

Spare SSR Playback opportunity

TDRS Vectors
S/C Vectors (Daily)
ATC Load
UTI-UTC

Time Correction as required

S-band Ku-band transponders commanded OFF via ATC at SHO stop time
TONS OBDC disabled

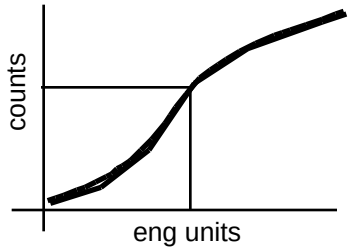
EOC Spacecraft Monitor Operations

EOS Operations Center

Each contact (8 to 12 min x times per orbit)

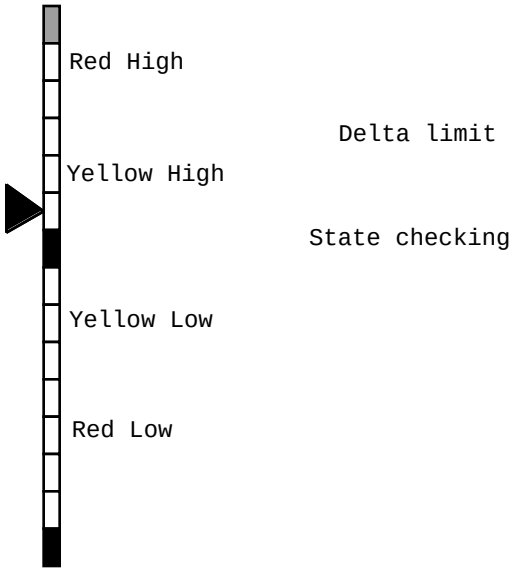
Real-time housekeeping telemetry

Decom
Convert
Calibrate
Limit check *Alarm ---> analysis ---> action (procedure)*
Display



Real-time commands ***(if required)***

Continuous housekeeping telemetry ----> SSR HK buffer
LRS Buffer



Once per day *(minimum)*

Playback telemetry one full orbit ***(minimum)***
(System capable for 100% of PB Tlm)

Decom
Convert
Calibrate
Limit check
Display
Trend ***---> short term, long term***
Analysis ***------> Tables, Plots ---> analysis ---> performance ----> action (procedure)***

FOT's 3-Step Approach for Real-Time Support (Cont'd)

- **Step 2: Contact**
  - **Starts at AOS, ends at loss of signal (LOS)**
  - **Involves executing sequence of activities briefed by Operations Controller during step 1**
  - **Initiates and monitors SSR playback**
  - **Involves monitoring spacecraft and instrument telemetry and executing FOT evaluation checklists**
  - **Executes standard operating procedures for all expected commanding**
  - **Executes appropriate contingency operations procedures when anomalies are seen in telemetry**
  - **Coordinates with EDOS and IOTs on data quality, as needed**

FOT's 3-Step Approach for Real-Time Support (Cont'd)

- **Step 3: Postcontact**
  - **Starts at LOS**
  - **Online engineers report status to Operations Controller**
  - **Command activity controller evaluates rate-buffered data transferred from EDOS**
  - **IOTs involved in command activities report status to Operations Controller**
  - **Operations Controller briefs NCC and EDOS on link status during contact**
  - **Online engineers initiate analysis requests, as instructed**

FOT's 3-Step Approach for Real-Time Support (Cont'd)

	Task	Time
Precontact (Step 1)	– Check ground script execution – Configure EOC – Conduct EDOS communication test – Conduct NCC communication test – Perform NCC performance data request – Confirm IST connectivity (as applicable) – Conduct precontact briefing	Contact –20 minutes
Contact (Step 2)	– Monitor spacecraft and instrument subsystem telemetry – Monitor state check – Perform and monitor SSR playback – Monitor SCC activity log and dump – Monitor clock correlation, updates – Uplink ATC load – Uplink spacecraft and TDRS ephemeris loads – Uplink microprocessor loads – Monitor maneuvers – Respond to command request – Coordinate with EDOS and IOTs, as needed	12-minute contact
Postcontact (Step 3)	– Conduct postcontact briefing – Ingest SSR data from EDOS – Perform postcontact analysis	Contact +20 minutes

SSR Management

- FOS SSR management tool provided to FOT
- FOT goal is 100-percent science data capture
- Average playback time is 6 minutes (full requires 17 minutes)
- Five SSR buffers are defined on AM-1 spacecraft
  - Low-rate science
    - » CERES
    - » MOPITT
    - » Housekeeping
    - » Ancillary data
  - MISR
  - MODIS
  - ASTER
  - Trash

SSR Management (Cont'd)

- Receive pass schedule and SSR buffer playback sequence from planning and scheduling system
- Generate SSR playback command sequences
- Submit command requests to FOT
- Monitor
  - SN user performance data (UPD) for Ku-band link status
  - Telemetered SSR buffer counters
  - EDOS CODAs for data capture and data quality
  - Track data losses and recapture data
- Feed back "as flown" data to planning and scheduling to update SSR data volume models
- Generate postpass reports

SSR Analysis Window

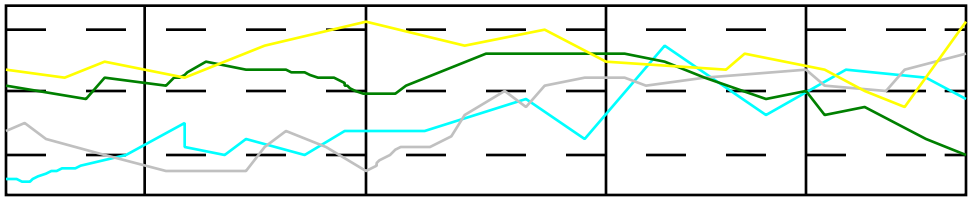
SSR Analysis

SSR Health and Safety

PB Clock Present:	On	Memory Config Ind:	On	Replay:	On
Memory Power Status:	On	Temperature:	10 C	Playback:	Off
Built in Test Ind:	On	Overwrite Status:	Off	Instant Replay:	Off
Low Power Ind:	On	Watch Dog Timer:	Off	Record:	Off
				Standby:	Off

SSR Buffer Counters

	Playback Counter	Record Counter
LRS	000	820
MISR	000	560
MODIS	630	000
ASTER	000	620
TRASH	000	700



Problems/Solutions

95/193/18:14:00.857	LCP	Forward link has failed: xxxxxxxxxx
95/193/18:14:01.030	LCS	Send a GCMR: xxxxxxxxxx
95/193/18:17:20.920	DRP	Bad data quality
95/193/18:17:22.532	DRS	Replay SSR

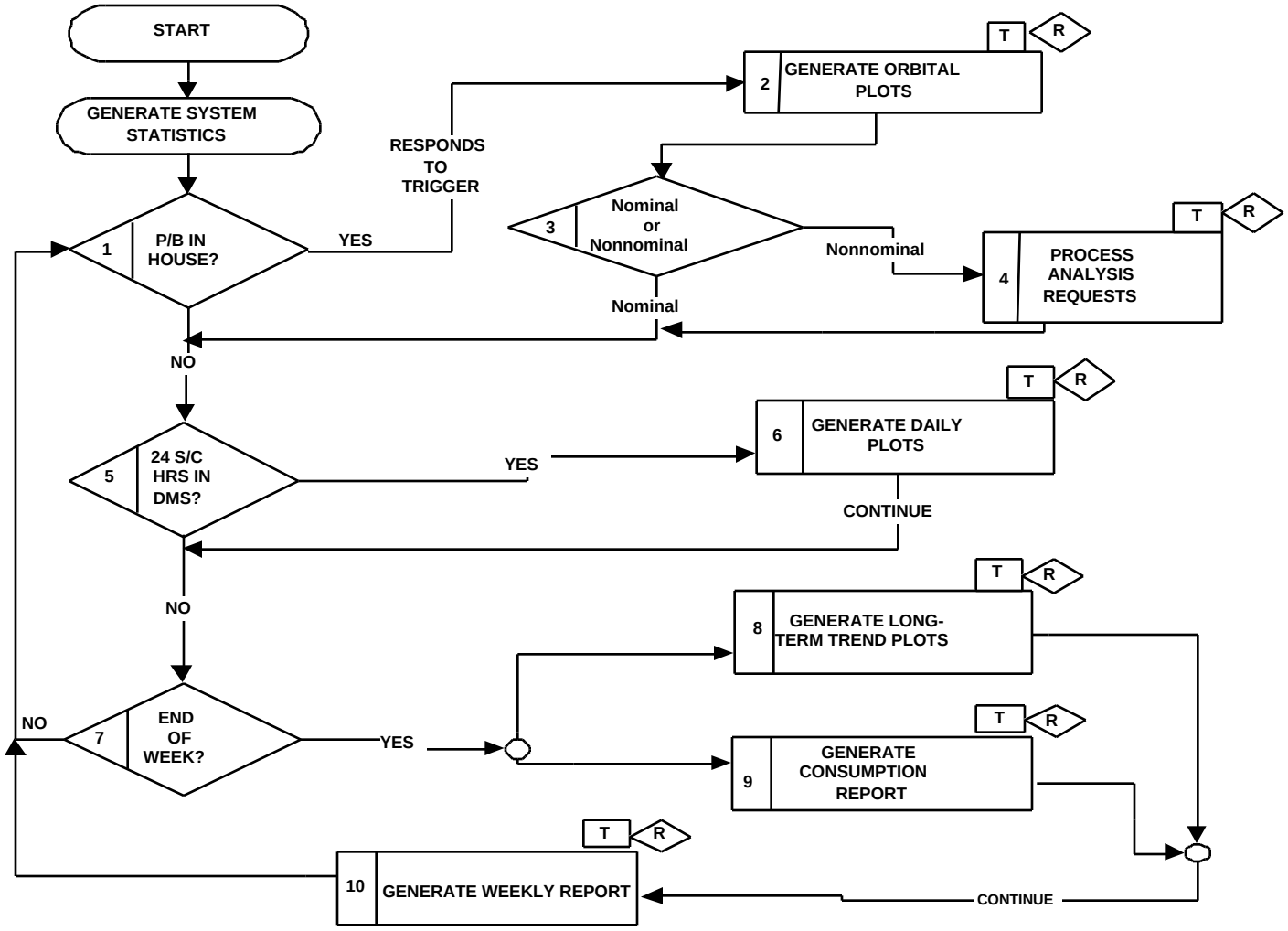
Clock Correlation

- FOT uses multistep approach to clock correlation
  - Execute Return Data Delay (RDD) technique on all real-time contacts (coarse estimate of clock error is provided to FOT in real time)
  - Execute USCCS technique on all coherent contacts
    - » Accurate estimate of clock error is obtained postcontact
    - » User-defined limits are set to alert FOT of need to steer master oscillator frequency (predefined procedures, commands, and tables on system)
    - » Master oscillator frequency behavior trends are statistically analyzed

Analysis Operations Baseline

- Goal is to capture 100 percent of housekeeping telemetry
- Execute predefined analysis requests against each housekeepiong playback
- Perform short-term analysis
  - Evaluate back-orbit AM-1 subsystem performance
  - Evaluate subsystem performance trends
- Perform long-term analysis
  - Perform statistical evaluation of subsystem performance trends
  - Estimate subsystem EOL targets
  - Formulate operations and environment modifications to extend subsystem component life
  - Identify non-nominal subsystem performance

Telemetry Analysis



Decision Support System

- FOT will use DSS to
  - Monitor real-time telemetry
  - Provide expert recommendations for
    - » Limit violations
    - » Telemetry link failures
    - » Bus and instrument configuration identification
    - » SSR management
    - » Spacecraft activity log interpretation